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FIRE REGIMES ON THE CARIBOU NATIONAL FOREST SOUTHEASTERN IDAHO

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FIRE REGIMES ON THE CARIBOU NATIONAL FOREST

SOUTHEASTERN IDAHO

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TABLE OF CONTENTS

page

INTRODUCTION 1

RESULTS AND DISCUSSION 2

Landscape Fire Patterns 2

Stand Fire Patterns 6

Fire Group 2 (Cool-dry Douglas-fir hts) 6

Fire Groups 3/4 (moist Douglas-fir/aspen) 9

Fire Groups 6/4 (lower- to mid-subalpine/aspen) 11

Implications for Ecosystem Management 15

LITERATURE CITED 21

APPENDIX A: Master Fire Chronology (A.D. 1269-1994) 23

APPENDIX B: Preliminary estimate of mean acres burned per year according to major cover types on the Caribou National Forest, based on presettlement fire frequency 25

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INTRODUCTION

During the summer of 1994, fire history sampling was conducted on the Caribou National Forest, southeastern Idaho. The goal was to determine fire regime patterns for the area's major forest types, to supplement the forest plan revision and to assist the development of strategies for ecosystem management. Specific objectives were to determine presettlement fire patterns and to interpret the possible effects of modern fire suppression on area forests. The sampling focused primarily on the area's 2 major forest cover types, that is, Douglas-fir- and aspen dominated stands. However, data also were obtained from stands that are dominated by lodgepole pine, and by subalpine fir and Engelmann spruce. Because the sample area contains considerable vegetative diversity, the sampling plan was to select a number of elevational road transects traversing representative terrain in several of the area's relatively widely separated mountain ranges. Three sample areas were chosen after consulting with national forest personnel. The first was in the Portnuef Range, using the Inman Creek- and Pebble Creek forest roads. The second sample area was in the Bear River Range, traversing forest roads through Strawberry Canyon, North Canyon, Meadow Creek, Eightmile Creek, and Ant and Cheatback Basins. The third sample area was in the Aspen Range, in the Left Hand-, Right Hand-, and main forks of Georgetown Creek. Accordingly, 50 plots were sampled along 8 road transects (see enclosed location maps).

The methods of Arno and Sneck (1977) were used to document fire history, specifically, a chainsaw was utilized to collect fire scar specimens in the representative stands. After field data collection, the samples were prepared and dated in a laboratory. Master fire chronologies then were developed for each sample stand by adjusting fire scar dates among adjacent sample trees. Based on these chronologies, fire history statistics such as mean fire intervals (MFI), fire interval ranges, and years since last fire were estimated

history has been severely depleted by several major fire years (e.g. 1745, 1781, 1844, 1934), evidence of which was found in the 3 widely separated mountain ranges. At least 53 fire years occurred between ca.1269 and 1967, yielding an area MFI of 13 years. Because of the depleted evidence over time, this statistic undoubtedly is conservative, and MFI was just 6 years during the period of relatively complete data (i.e. post-1745). There were as many as 7 major fire years between 1745 and 1934 (defined as occurring in at least 2 or more of the sampled mountain ranges and in at least 10% of the sample plots). This yields an MFI of about 32 years between major events. The last major fire year occurred 60 years ago, in 1934.

Importantly, the master fire chronology suggests that only one fire-free decade occurred in the 222 years between 1745 and 1967. However, when fire frequency is expressed in terms of the number of affected sample plots, there has been a trend toward declining fire frequency since the 1880s (Appendix A). Presumably this is due to European settlement of the region--that is, the onset of longterm overgrazing and increasingly efficient fire suppression (Houston 1973, Loope and Gruell 1973, Gruell 1980, Arno and Gruell 1986, Barrett 1994; and discussed below).

Overall, these data indicate a very high presettlement fire frequency for the Caribou National Forest. Indeed, when considering the relatively limited geographic scope of this sampling, MFI likely would approach just one year if it were possible to sample the entire Forest. That is, spreading fires caused by lightning and humans probably occurred somewhere on the Forest virtually every fire season before the late 1800s. Note that the area MFI refers only to "fire year" frequency; since dozens of fires can occur during a single fire season, both the fire frequency and the degree of landscape affected is remarkable. The presettlement fire history on the Caribou is especially noteworthy when considering that modern fire activity has been relatively

negligible (unpub. repts. on file, Caribou NF). This factor, in addition to the inherently more difficult sampling in Douglas-fir forests, can contribute to a misimpression that fire has played a minor role in area forests (pers. comm. with D. Bull, Staff Officer, Caribou National Forest). Therefore, from a forest planning perspective, fire history sampling has been timely and should be useful for future ecosystem management activities (discussed below).

In terms of characteristic fire regimes, several factors indicate that a short- to moderately long interval/mixed severity regime was the predominant fire regime type in this area of southeastern Idaho. ("Mixed severity" regime refers to fires that can produce the full range of severities, from non-lethal to total stand replacement, both during a single fire event and between consecutive events). First, the Caribou Forest has a complex forest mosaic of variable aged stands that are dominated by Douglas-fir, aspen, lodgepole pine, or spruce and subalpine fir (GIS on file, Caribou NF). Second, the sampling revealed that most conifer stands contain multiple fire-intitiated age classes, but some small stands are 1-aged (e.g. aspen- and spruce/fir cover types [Fire Groups 4 and 6; Bradley et al. 1992]). As further evidence of mixed severity fires, fire scars were found on virtually every tree species in the area, even on highly fire sensitive species such as aspen, spruce, and subalpine fir. Finally, aerial photographs and field observations indicated that fire-induced mosaics usually are relatively indistinct (i.e., displaying poorly defined burn margins), as opposed to the readily visible burn margins that occur under a stand replacement regime. This landscape pattern, in addition to the data in the master fire chronology, suggests that most fires were patchy and only rarely burned extensive areas. (Intensive sampling in a large study area encompassing several contiguous drainages would shed more light on these large-scale fire patterns).

In the absence of spreading fires over the last 100 years, many forest

mosaics have aged more uniformly and have become increasingly homogeneous (Gruell 1980). Consequently, long fire intervals and the subsequent increase in live and dead fuels have increased the likelihood of altered fire regimes at both the landscape and stand scales (discussed below).

Stand Fire Patterns.

Fire Group 2 (Cool-dry Douglas-fir habitat types). One objective of the sampling was to obtain data from the area's sparsely forested south slope communities, which are dominated by only scattered Douglas-firs, limber pines, and junipers. Because of severe microsite drought and light flashy fuels, these communities likely had the most frequent fires of any forest type in the area (Houston 1973, Arno 1980). However, few data previously had been available (cf. Bradley et al. 1992) because fire history sampling is problematic in these communities. First, these ecosystems typically lie adjacent to main valley bottoms, and longterm use by humans (i.e. tree harvesting, fire suppression, livestock grazing) has altered lower elevation ecosystems to such a degree that evidence of fire history has been severely depleted. Second, in relatively intact stands, the naturally sparse and patchy fuels greatly reduce the likelihood that mature trees will sustain fire scars. As described previously, few dry-site Douglas-firs were found with catfaces, and the easily scarred limber pine apparently rarely sustains more than 1 or 2 scars before succumbing to carpenter ants. Some scars were found on Rocky Mountain juniper, but these were were problematic in terms of scar identification and dating.

Data were obtained from 3 stands in Fire Group 2 (table 1). Results suggest that a short interval/non-lethal fire regime characterizes habitat types in the dry Douglas-fir series, for example, PSME/BERE-SYOR and PSME/SYOR. For example, near "Tat's Tree" in lower North Canyon (Bear Rv. Range), a 60 inch

Table 1. Fire occurrence data from 3 plots in Fire Group 2 (cool-dry Douglas-fir habitat types), Caribou National Forest.

Plot No.[1]	Cover Type[2]	Habitat Type[3]	Fire Chronology	No. Fires[4]	MFI	Interval Range[5]	Yrs Since Last Fire[6]
6	DF/JUNIP	PSME/BERE-SYOR	1844-1934	5	23	9-40	60
15	DF/LIMB	PSME/SYOR	1690-1947	13	21	6-46	47
33	DF/JUNIP	PSME/BERE-SYOR	1791-1871	7	13	5-30	123
				RANGE:	13-23	5-46	47-123
				MEAN:	19	7-39	77

[1] Plot locations on maps enclosed with this report.

[2] Codes: DF(Douglas-fir) JUNIP(Juniper) LIMB(Limber Pine) ASP(aspen) LP(lodgepole pine) SP/F(spruce/fir)

[3] Acronyms follow Steele et al. (1983)

[4] Primarily non-lethal fires.

[5] "+" denotes incomplete interval.

[6] As of 1994.

dbh Douglas-fir (600+ yr old) had a catface along one edge of a large burl. This tree sustained at least 14 fire scars between 1602 and 1947, the largest number of fire scars yet reported for a speciman obtained from eastern Idaho or western Wyoming. This catfaced tree yielded a stand MFI of 21 years, but this estimate of fire frequency is conservative since other tiny fire scars clearly had been burned off the catface. Similarly, the shortest stand MFI in the data was obtained from a Douglas-fir in the lower Left Hand Fork of Georgetown Creek (Aspen Range), adjacent to south slopes dominated by juniper, limber pine, and mountain mahogany. The catface was heavily infested with carpenter ants but had 6 datable fire scars between 1805 and 1871, yielding a MFI of 13 years. Overall, the 3 stands in this cover type had an average MFI of 19 years between non-lethal surface fires, and individual intervals ranged from 7-39 years long, on average. Therefore, while evidently somewhat conservative, these presettlement frequency data represent the shortest intervals yet reported for Fire Group 2 in the region (Bradley et al. 1992).

As of 1994, the 3 sample stands had not experienced a fire in from 47 to 123 years--2 to 10 times longer than the pre-fire suppression MFIs. The 3-stand average of 77 years since the last fire is 4 times longer than the presettlement average interval, likely because of longterm overgrazing and fire suppression (Gruell 1980). Increased fuels and stand decadence is evident even on these dry unproductive sites. For example, dense patches of trees less than 100 years old and stands of overmature, decadent mountain mahogany frequently occur in a closed canopy configuration. Therefore, these unprecedented fuel buildups potentially have altered the previous fire regimes pattern from one of frequent light surface fires, to one of moderately long- to long interval fires that produce mixed severity burning or total stand replacement during wind driven events.

Fire Groups 3/4 (moist Douglas-fir h.t.'s; aspen). Fire history data were obtained from 19 plots in the montane Douglas-fir zone, that is, relatively productive stands typically on north slopes. Results indicate a short- to moderately long interval/mixed severity fire regime during the presettlement period (table 2). MFIs for Fire Group 6 and adjacent seral aspen stands having similar understory fuels ranged from 16 to 66 years between mixed severity underburns. The mean based on the 13 stands that yielded MFIs was 41 years. However, an overall mean interval of 53 years resulted for Fire Group 3 when data from stands displaying only single fire intervals were factored into the equation (i.e. weighted mean based on the average MFI and a multiple site average fire interval [MAFI][Barrett and Arno 1988]).

Fire interval variability was relatively high in these stands, ranging from as little as 5 years to as long as 100 years. However, the average range was 26 to 71 years, and comparatively long fire intervals (e.g. 100-125 yr) were uncommon. As of 1994, the years since last fire statistic ranged from 27 to 154 years in the 19 stands. However, the overall mean was 102 years--about twice the length of the presettlement average fire interval.

In summary, data from the Caribou National Forest indicate that pre-1900 fire frequency was comparatively high in Fire Group 3 stands. While some estimates for this fire group in Bradley et al. (1992) are generally accurate, the authors were forced to extrapolate data from studies over a broad geographic area of the Northern Rockies--not including southeastern Idaho. Consequently, a wider range of fire frequency is listed for this fire group--from 15 to 100 years (Bradley et al. 1992). Additionally, a number of MFIs in table 2 are substantially shorter than were previously reported for Douglas-fir stands in the region (Houston 1973, Loope and Gruell 1973, Arno 1981 [unpub.], Arno and Gruell 1986, Barrett 1994). Since most earlier studies produced only limited data, it remains unclear whether the data in table 2 simply reflect a

Table 2. Fire occurrence data from 19 plots in Fire Group 3 (moist Douglas-fir habitat types) and adjacent Fire Group 4 (aspen-dominated communities), Caribou National Forest.

Plot No.	Cover Type	Habitat Type	Fire Chronology	No. Fires[7]	MFI	Interval Range	Yrs Since Last Fire
1	DF	PSME/OSCH	1781-1878	3	49	35-62	116
2	DF/ASP	PSME/ACGL	1781-1934	4	51	24-79	60
3	DF	PSME/OSCH	1781-1884	4	34	33-35	110
4	LP/ASP	PSME/CARU-CARU	1878-1967	4	30	20-33	27
5	DF/ASP	PSME/OSCH	1769-1844	2	-	75	150
25	DF/ASP	PSME/OSCH	1805-1857	2	-	52	137
32	DF	PSME/OSCH	1791-1871	3	40	38-42	123
35	DF/ASP	PSME/CARU-CARU	1871-1934	5	16	13-26	60
38	DF/ASP	PSME/BERE-BERE	1745-1863	2	-	118	131
39	DF	PSME/PHMA-PAMY	1791-1884	4	31	21-43	110
40	DF	PSME/CARU-PAMY	1775-1906	3	66	43-88	88
41	DF	PSME/CARU-CARU	1763-1916	6	31	10-89	78
42	DF/ASP	PSME/BERE-BERE	1690-1919	10	25	5-48	75
43	DF	PSME/CARU-CARU	1824-1902	3	39	31-47	92
45	DF	PSME/OSCH	1650-1844	4	65	24-99	154
46	DF	PSME/OSCH	1781-1942	4	54	39-75	52
48	DF	PSME/OSCH	1871	1	-	123+	123
49	DF	PSME/BERE-BERE	1871	1	-	123+	123
50	DF/ASP	PSME/BERE-SYOR	1781-1871	2	-	90	123
				RANGE:	16-66	5-123+	27-154
				MEAN:	41	26-71	102

WEIGHTED MEAN (MFI+MAFI): 53 yr

[7] Primarily mixed severity fires.

greater sampling intensity, or portray actual ecological variance within southeastern Idaho, such as climatic or latitudinal effects.

Interestingly, the shortest MFIs in Fire Group 3 were obtained from stands adjacent to major valley bottoms. For example, stands 35 and 42 yielded MFIs of 16 and 25 years, respectively (table 2; enclosed plot location map). This might be attributable to an "edge effect", whereby trees adjacent to the most frequently burned ecosystems sustained the most frequent fire scars. However, the stand fire histories also probably reflect frequent human-caused ignitions occurring in and near valley bottoms. For example, Native Americans caused many fires in major travel zones in the Northern Rockies, both inadvertantly and by design (Barrett and Arno 1982), and early-day journals document a number of such instances in the valleys of eastern Idaho and adjacent areas (Gruell 1985). Early settlers also may have caused many fires, but this influence may have been partially offset by overgrazing practices that reduced fine fuels and limited fire spread.

Fire patterns for Fire Group 3 appear to exhibit less variation than for stands in the subalpine zone (Fire Group 6; discussed below). This may be attributable to the more uniformly steep and productive north slopes at lower elevations, as well as to the more uniform vegetation pattern (i.e. fewer comingled stands of aspen and other cover types). In Fire Group 6, by contrast, terrain- and mosaic diversity often increase with increasing elevation, promoting more variation in fire pattern.

Fire Groups 6/4 (lower- to mid subalpine h.t.'s; aspen). Data were obtained from 28 plots in Fire Group 6 and adjacent Group 4, and results indicate a moderately long interval/mixed severity fire regime (table 3). The most longterm data in the study were obtained from a downed Douglas-fir snag in upper Meadow Creek, at the edge of a meadow complex interspersed with aspen

Table 3. Fire occurrence data from 28 plots in Fire Group 6 (lower- to mid subalpine habitat types) and adjacent Fire Group 4 (aspen-dominated communities), Caribou National Forest.

Plot No.	Cover Type	Habitat Type	Fire Chronology	No. Fires[8]	MFI	Interval Range	Yrs Since Last Fire
7	SP/F	ABLA/OSCH-OSCH	1781	1	-	213+	213
8	LP/ASP	ABLA/ARLA	1816-1934	5	30	5-45	58
9	SP/F	ABLA/OSCH-OSCH	1690	1	-	304+	304
10	SP/F	ABLA/OSCH-PAMY	1816	1	-	178+	178
11	LP	ABLA/VAGL-PAMY	1844-1871	2	-	27	123
12	LP	ABLA/VAGL-PAMY	1871-1934	2	-	63	60
13	SP/F	ABLA/VAGL-PAMY	1727-1857	4	43	13-89	137
14	LP/DF	ABLA/OSCH-OSCH	1805-1919	5	29	15-53	74
16	DF	ABLA/OSCH-OSCH	1897	1	-	97+	97
17	LP	ABLA/OSCH-OSCH	1745-1959	5	54	25-92	35
18	DF	ABLA/OSCH-OSCH	1745-1897	2	-	152	97
19	SP/F	PIEN/RIMO	1745	1	-	249+	249
20	DF/ASP	ABLA/OSCH-OSCH	1269-1851	10	65	25-108	141
21	SP/F/ASP	ABLA/ARLA	1745-1947	2	-	202	47
22	DF/ASP	ABLA/OSCH-PAMY	1655-1947	4	97	60-142	47
23	LP	ABLA/VASC-VASC	1655-1894	2	-	239	100
24	LP/DF	ABLA/OSCH-PAMY	1781-1871	2	-	90	123
26	DF/SP/F	ABLA/VAGL-PAMY	1884-1947	2	-	63	47
27	DF/LP	ABLA/OSCH-PAMY	1884-1947	2	-	63	47
28	ASP/LP	ABLA/OSCH-OSCH	1857-1947	3	45	27-63	47
29	LP	ABLA/ARLA	1871-1903	2	-	32	91
30	DF	ABLA/OSCH-PAMY	1745-1903	3	79	32-126	91
31	DF/ASP	ABLA/OSCH-PAMY	1745-1934	5	47	20-101	60
34	LP	ABLA/CARU-CARU	1871-1934	2	-	63	60
36	LP/ASP	ABLA/CARU-CARU	1871	1	-	123+	123
37	LP	ABLA/CARU-CARU	1863-1916	2	-	53	78
44	DF/ASP	ABLA/CARU-CARU	1871-1902	2	-	31	92
47	LP/DF	ABLA/CARU-CARU	1769-1871	2	-	102	123
			RANGE:	29-97		5-304+	35-304
			MEAN:	54		25-113	105

WEIGHTED MEAN (MFI+MAFI): 97 yr

[8] Primarily mixed severity fires.

groves and north slope Douglas-fir stands. This tree, evidently killed by a fire in about 1851, had an estimated pith date of 1269 and an 8-scar sequence spanning from ca.1319 to 1746. The stand MFI was 65 years, slightly longer than the average MFI based on 9 plots in the subalpine zone (table 3).

Stand MFIs for Fire Group 6 and adjacent aspen stands ranged from 29 to 97 years between mixed severity underburns. The average MFI based on the 9 stands yielding MFIs was 54 years, about 15 years longer than in Fire Group 3 (tables 2,3). However, variability was quite high both in terms of frequency and severity, and an overall weighted mean of 97 years resulted for this Fire Group--nearly twice the mean for Fire Group 3. The predominant fire pattern was still one of mixed severity underburns--with occasional exceptions, for example, in the spruce/fir cover type. Fire scars from sub-lethal underburning can be found even in spruce-dominated stands, largely on gently sloped terrain, but long intervals between stand replacing fires (e.g. 200-300 yr) also sometimes occurred. Actual interval lengths ranged widely, from as short as 5 years to as long as 304 years, but the mean range based on all 28 plots was 25 to 113 years. The years since last fire statistic also was highly variable, from 35 to 304 years, and the 28 stand mean was 105 years. This is roughly equivalent to the overall mean fire interval, but twice as long as the presettlement average MFI for 9 stands. These data suggest a general trend toward declining fire occurrence since the late 1800s, at least in the most frequently underburned stands.

The highly variable fire patterns for this fire group can be attributed to many factors. For example, this group contains widely differing terrain types, site productivities, individual stand histories, stand fuel amounts and structures, varying stand successional status and forest cover types, and a high degree of complexity in the vegetation mosaic. Some of these fire frequency data also are substantially shorter than previously reported for this

fire group (Bradley et al. 1992). Some level of extrapolation error is likely in Bradley et al. (1992), since the Caribou sampling represents the first fire history data set for eastern Idaho, and the most southerly sampling of Douglas-fir dominated stands to date. In terms of Fire Group 6, however, southeastern Idaho also apparently contains a greater proportion of Douglas-fir dominated stands than elsewhere in the region, (i.e. drier habitat types). Therefore, the less frequent occurrence of the generally longer interval spruce/fir forests may render a shorter overall fire frequency for this fire group on the Caribou.

It is important to note here that the wide range of fire intervals that were sampled for Fire Groups 3 and 6 also are considered to be representative of fire frequency in adjacent aspen stands with similar understory fuels (e.g. POTR-PSME/CARU, POTR-PSME/SYOR, POTR-ABLA/SHCA hts). Longterm fire history data from scars and age classes generally are unavailable in the highly fire sensitive aspen stands, necessitating the extrapolation of fire frequency from adjacent conifer stands. Extrapolation is especially appropriate when conifers occupy seral aspen stands, because conifers significantly increase stand flammability (Brown and Simmerman 1986).

Conifer-aspen plots are noted in tables 2 and 3. Since most aspen are readily killed by fire, these data should be considered representative of the range of intervals for aspen stand replacement. That is, fires spreading through aspen generally caused total stand replacement, but gently sloped terrain occasionally also contains 2-aged stands with fire scars on members of the older aspen class. Two-age stands co-dominated by aspen and lodgepole pine also exist, for example, near Cheatback Basin. However, these sites had burned in the 1940s, and scarred aspen likely cannot persist for more than a few decades before succumbing to heart rot (Bradley et al. 1992). This represents one of the few such cases documented in the literature (i.e. 2-age aspen stands

with basal fire scars).

Data in tables 2 and 3 suggest the following for aspen fire frequency: in 9 conifer-aspen stands, MFIs ranged from 16 to 97 years and the average MFI was 45 years. The latter statistic is similar to Arno's (1981 unpub.) estimate for conifer-aspen stands in lower Fontenelle Creek, western Wyoming. Conversely, 7 conifer-aspen stands yielded only single fire intervals (i.e. no MFIs) that ranged from 31 to 202 years, and MAFI was 99 years. When the MFI and MAFI data are combined for a weighted mean, an average fire interval of 69 years results for the aspen cover type. Results thus suggest wide variability in fire occurrence within the aspen-conifer mosaic. However, while these data represent the most extensive fire history sampling of western aspen to date, more information would be required to compile an adequate data base for the type.

The longest fire intervals in aspen likely occur in stands with dense forb understories lacking a conifer component (Brown and Simmerman 1986). Conversely, shorter intervals evidently occur in aspen stands that have substantial numbers of conifers and a grass/shrub understory. In terms of planning for prescribed fire and wildfires, therefore, the wide array of aspen habitat types can serve as a useful guide for predicting fire behavior and post-fire successional patterns (Steele et al. 1983, Brown and Simmerman 1986, Bradley et al. 1992).

Implications for Ecosystem Management. This fire history sampling points to some difficult challenges for future ecosystem management in Fire Groups 2, 3, 4, and 6 on the Caribou National Forest. The unnaturally long fire intervals that exist in many stands today raise the specter of altered fire regimes during this century. Before 1900, most conifer stands were maintained in a multi-aged configuration by recurrent underburns. However, longterm

overgrazing and fire suppression apparently have precluded as many as 3 or 4 fire "thinning" treatments in many stands over the past 100 years. And, as many as 9 or 10 fire cycles may have been preempted in the driest ecosystems. Relatively widespread decadence is readily visible in many older stands on the Caribou, and a major outbreak of Douglas-fir beetle has occurred in recent years (McPherson Timber Sale Environmental Analysis; unpub. rept. on file, Caribou NF). Clearly, insects have temporarily supplanted fire's role in removing old age classes that would have been heavily thinned by multiple fires over the past 100 years.

Perpetuation of fire-dependent aspen is another serious management concern with respect to longterm fire exclusion. For example, DeByle et al. (1987) analyzed wildfire occurrence in aspen between 1970 and 1982 in the Interior West. An annual average of only 600 acres had burned in that cover type and, at that rate, 12,000 years would be required to burn an area equivalent to the entire aspen acreage in the West. My sampling to date appears to verify this general trend, since results suggest that an annual average of 2200 acres of aspen would be expected to burn on the Caribou National Forest alone (Appendix B and discussed below).

In addition to promoting decreased stand vigor and a subsequent increase in insect epidemics, fire exclusion has promoted an increase in live and dead fuels at both the stand- and landscape scales (Brown et al. [in press]). At the broad landscape scale, for example, an overall decrease in spreading fires during this century has encouraged a more uniform aging of vegetation mosaics (Gruell 1980), thus a widespread increase in mosaic homogeneity. Therefore, in direct contrast with the anti-timber harvest policies that are driving much of forestry today, results from numerous fire history studies suggest that an aggressive silvicultural program is critically necessary for restoring the ecological integrity of forests under non-lethal or mixed severity fire

regimes. Without a program of restoration silviculture covering many tens of thousands of acres, the longterm fuel buildup at the stand- and forest mosaic levels will continue to promote a shift toward stand replacement fire regimes.

Knowledge of past fire patterns and altered fire regimes in this century can aid the development of management strategies that maintain or restore stands to a semblance of natural succession. If additional fire history data were obtained for the Caribou National Forest, results could be stratified into fire regimes models for GIS mapping (cf. Barrett and Arno 1991) for use in various planning aspects. As one example of a GIS application, when the total acreage for each cover type on the Forest is divided by sampled fire frequencies, estimates can be made of the average number of acres that burned per year under natural fire regimes (Appendix B)(Barrett and Arno 1991, Brown et al. [in press]). This can help prioritize and set targets for vegetation manipulation with silviculture and/or prescribed fire. For example, assuming that the 19 year MFI for Fire Group 2 (table 1) represents a conservative estimate of fire frequency in the most frequently burned ecosystems (sagebrush/grass, juniper, mountain shrub, limber pine), then an average of at least 36,000 acres of the approximately 680,000 total acres occupied by these cover types would be expected to burn annually (i.e. 5 percent per year). Additionally, based on the data to date, an average about 2200 acres of aspen, 2200 acres of montane Douglas-fir, and 2400 acres of subalpine habitat types might be expected to burn annually (1-2% per year). When summed, these estimates total about 4 percent of the total land area per year (42,600 ac), thus suggesting that 25 years would be required to burn an area equivalent to the entire Caribou National Forest (Appendix B; preliminary estimates only). Moreover, since fire interval data also were obtained for the fire suppression period, the model could be adjusted to reflect any "preempted" acreages that might have burned in this century. That is, the average number of years since last fire in each

cover type could be factored into the model to increase ecosystem management targets where appropriate. Proposed treatments also could be reduced in scope where modern wildfires had burned extensive areas, thereby surpassing the average number of burned acres over time.

Fire history data can be used to guide the selection of various types of ecologically appropriate stand treatments, when the goal is to restore or maintain natural stand conditions. (Post-fire successional models depicted in Bradley et al. (1992) can provide further predictive capability when used in conjunction with the fire regimes information). Stands in Fire Group 2 evolved with frequent underburns that helped shape uneven-age stands, therefore, uneven-age management and maintenance underburning is indicated on the few sites that are capable of sustaining silviculture. However, intensive silviculture often is economically unfeasible on unproductive sites, and can be harmful on sites with thin-mantled soils. The most practical alternative for ecosystem management in Fire Group 2 may be to conduct prescribed underburning during moderate fire weather. This approach could achieve some stocking reduction, but would have only limited effectiveness given the high fire resistance of mature Douglas-fir. And while spring burning can rejuevenate overmature shrubs for wildlife browse, reintroduction of fire after comparatively long intervals might well promote increased fire hazard in the immediate post-fire stand. For this reason, re-application of low intensity prescribed fires after relatively short intervals (e.g. <10 yr) might be the most effective way to reduce the likelihood of crown fires on south slope communities.

Unlike on the driest cover types (e.g. Fire Groups 1, 2), where soils typically are highly unstable, the concept of restoration silviculture has direct applicability to many montane and subalpine stands where soils are capable of supporting intensive silviculture (e.g. Fire Groups 3, 4, and 6).

For example, the past pattern of mixed severity fires occurring after widely varying intervals suggests broad latitude in selecting and scheduling ecologically appropriate silvicultural systems. Presettlement fire regimes suggest a mix of even-age and uneven age systems for relatively productive sites, because past fires produced both multi-age stands and small even age groups in a diverse mosaic. For aspen, small clearcuts and/or prescribed fires would best emulate the past recycling and perpetuation of stands in openings within the conifer forest.

Initially, most conifer stands would need to be heavily reconfigured to remove the pole thickets that have regenerated in fire's absence, especially on past high-graded sites. An aggressive fuel reduction program composed of commercial thinnings and prescribed fire would help diversify stand structures and the uniformly aging landscape mosaic, hence reducing the likelihood of widespread stand replacement during future wildfires. Unfortunately, in conifer stands where a number of fire cycles have been excluded to date, treatment with prescribed fire alone would not be an effective means of achieving the necessary stocking reduction. That is, prescribed underburning is not recommended without prior silvicultural thinning (ideally employing whole tree harvests wherever possible). Such fires either would be ineffective, as has been amply demonstrated by numerous spring burning programs in the West, or would be largely lethal in overstocked stands during more critical fire weather. Burning without prior stand thinning also might create a subsequent wildfire hazard (i.e., severe reburns in post-fire fuels).

To help guide the selection and scheduling of various silvicultural and prescribed fire treatments, the fire history data, plot location maps, and existing fire atlas maps can help identify which areas still have relatively unaltered fire cycles, and which stands have not burned in this century (e.g. tables 1-3; enclosed plot location map). In the few relatively recently burned

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Loope, L. L., and G. E. Gruell. 1973. The ecological role of fire in the Jackson Hole area, northwestern Wyoming. Quat. Res. 3: 425-443.

Steele, R., S. V. Cooper, D. M. Ondov, D. W. Roberts, and R. D. Pfister. 1983. Forest habitat types of eastern Idaho-western Wyoming. USDA For. Serv. Gen. Tech. Rept. INT-144.

APPENDIX A

MASTER FIRE CHRONOLOGY (A.D. 1269-1994)
CARIBOU NATIONAL FOREST

	Portneuf Range	Bear Rv. Range	Aspen Range	
1967	1 plot	1		
59		1		
47		5		(10%)
42	1			
34	2	6	2	(20%)
29		1		
19	1	2		
16			2	
10		2	1	
06			2	
03		3		
02	3			
1898	1			
97		4		
94		1		
93			1	
84	2	5	2	(18%)
78	2			
71	7	6	5	(36%)
63			5	(10%)
60	1			
57		3	1	
53		2		
44	4	6	1	(22%)
34			1	
29		1	2	
24	3			
16	2	2		
05		5	1	(12%)
1791		1	3	
81	6	2		(16%)
76	1			
75			2	
69	2			
63			1	
45	1	8		(18%)
39		1		
36	1			
27		2		
24	1			
19		1		
1696		1		
90	1	3		
74	1			
55		2		
50	1	1		

APPENDIX A (cont.)

Portneuf Range	Bear Rv. Range	Aspen Range
1602	1	
1580	1	
55	1	
1459	1	
1359	1	
18	1	
1269	1	

APPENDIX B

Preliminary estimate of mean acres burned per year according to major cover types on the Caribou National Forest, based on presettlement fire frequency.

Fire Group	Cover Type	Total Acres on Forest[9]	MFI	Acres Burned Per Year
1&2:	Junip, limber pine, mtn brush, sage/grass	682,000	19	35,895
3 :	Douglas-fir	115,000	53	2170
4 :	Aspen	152,000	69	2203
6 :	Lower-mid subalpine hts	232,000	97	2392
	TOTALS:	1,181,000		42,660 (4%)

[9] From Caribou National Forest GIS